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RUTGERS • THE STATE UNIVERSITY

YEAR-AROUND OPERATION OF COLLEGES

An Analysis of the Advantages and Disadvantages of Various Operating Schedules

ELMER C. EASTON
Dean, College of Engineering
Rutgers • The State University

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I. INTRODUCTION

The purpose of this bulletin is to consider some of the major factors involved in changing the academic schedule of a university from the standard two-semester calendar year to a program under which instruction is carried on throughout almost all of the calendar year. Comparisons will also be made with the three-quarter year.

At the present time, when the nation's colleges are facing the problem of expanding to accommodate a rapidly growing population, those who will have to pay for new buildings are becoming increasingly critical of the partial idleness of educational facilities or their use for purposes other than degree programs during three months of the year. There is a reluctance to provide new buildings when it appears as though much of the problem could be solved without construction by simply changing the operating schedule.

This study will attempt to show the possible advantages of year-around operation as well as the factors which must be given up to permit such operation. It will then be possible to weigh the gains against the losses to determine the value of the change.

The analysis will be based only on daytime functions of the university and will not involve evening classes. The effect of evening work may be readily added by the reader, using the techniques which will be developed. However, in most cases the conclusions reached by studying the day programs will not be affected by adding the night programs. The numerical values used in the analysis will be derived from average practices in American engineering colleges. It will nevertheless be readily apparent that many of the conclusions can be carried over to other types of colleges. The techniques of analysis may be employed by the reader using figures which pertain specifically to his institution.

II. DEFINITIONS

It is immediately evident upon starting work of this sort that certain common words are used in a confusing way. For example, the word "semester" means a period of six months and is derived from the Latin sex (six) + mensis (month). In practice it is used to describe a college term of approximately 15-17 weeks. The word "trimester" means a period of three months (tres + mensis), but in academic circles it seldom has that significance.

In an effort to avoid semantic confusion, the word "term" will be used in this discussion to denote one complete segment of an academic program starting with registration, including an unbroken period of instruction, and concluding with examinations.

Present Standard Schedule

For the purposes of this study it will be assumed that the present standard "two-semester year" covers a total period of 37 weeks, consisting of 30 weeks of instruction, four weeks of examinations and registration, and three weeks for such things as freshman orientation, Christmas recess and spring recess.

Year-Around Schedule

During most of the analysis, year-around operation will be assumed to involve dividing the calendar year into three terms of 16 weeks each plus approximately four weeks for vacations and holidays. (This division is arbitrary. The reader who wishes to study other schedules may do so by employing the techniques developed herein. A four-term year will be considered later.) Each 16-week term will provide 14 weeks for instruction plus two weeks for examinations and registration. An academic year will be assumed to be made up of two terms including 28 weeks of instruction (less one or two holidays) and four weeks of examinations and registration. As in the present standard program, four academic years (eight terms) will be required for the bachelor's degree, two terms for the master's degree, and four additional terms for the doctor's degree. Vacations for students and faculty will consist of 16 to 19 days in the summer plus a 9 or 10-day period including Christmas Day and New Year's Day. (Of course, if the traditional Christmas recess were eliminated, a longer summer vacation would be possible.) Holidays for students and faculty will include Good

Friday, Fourth of July, Labor Day and Thanksgiving Day. A typical schedule based on 1957-58 would be as follows (all dates inclusive):

Terms Start Terms End	Sept. 3 Dec. 23	Jan. 2 April 24	April 25 Aug. 15
Vacations Start Vacations End	Dec. 24 Jan. 1		Aug. 16 Sept. 1

Various operating schedules will be studied within the framework of this three-term calendar year.

Student Symbols

Letter symbols will be used to designate particular groups of students. Thus F will be freshmen in the first term of the first academic year, while F' will be freshmen in the second term. D_1 will represent doctoral candidates in the first term of the second graduate year (first year after the master's degree) and D'_2 will denote doctoral candidates in the second term of the final year. Analogous symbols refer to sophomores, juniors, seniors and candidates for the master's degree. The complete set of symbols is shown below.

Academic Year	1		2		3		4		5		6		7	
Term	1	2	1	2	1	2	1	2	1	2	1	2	1	2
Symbol	F	F'	S	S'	J	J'	$\underline{S}$	$\underline{S}'$	M	M'	D_1	D'_1	D_2	D'_2

An entire undergraduate class will be denoted by the letter C in the first term. Thus $C = F + S + J + \underline{S}$.

III. NUMERICAL VALUES

Distribution Among Classes

It will be found convenient to relate the size of the various groups of students to C. On the undergraduate level this has been done by computing average values for all American engineering colleges from enrollment figures given in the annual reports of the American Society for Engineering Education. Attrition between first and second terms was estimated from a small actual sample. Ratios for graduate students were obtained by assuming that 25% of the B. S. holders will enroll toward the M. S. degree, while 10% of the B. S. holders will enroll for the Ph. D. after obtaining the M. S. The numbers of students receiving the B. S., M. S. and Ph. D. degrees each year from one class (G_B, G_M and G_D respectively) have also been expressed in terms of C based on national averages. All ratios are shown in Table 1.

Table 1

CLASS AND DEGREE DISTRIBUTION IN TERMS OF C

$$C = F + S + J + \underline{S}$$

$F = 0.330C$	$F' = 0.273C$
$S = 0.244C$	$S' = 0.224C$
$J = 0.217C$	$J' = 0.211C$
$\underline{S} = 0.209C$	$\underline{S}' = 0.205C$
$\overline{M} = 0.0422C$	$\overline{M}' = 0.0414C$
$D_1, D'_1, D_2 = 0.0169C$	$D'_2 = 0.0166C$
$G_B = 0.169C$	$G_D = 0.0132C$
$G_M = 0.0393C$	

Class Sizes and Teacher Demand

Any study of year-around operation must include a determination of the number of faculty members needed and the efficiency with which they are used. For this purpose the following arbitrary assumptions will be made regarding teaching loads and class sizes:

1. Undergraduate teaching load = four sections (twelve credit hours).
2. Graduate teaching load = three sections (nine credit hours) or equivalent.
3. Size of sections as in Table 2.

Table 2

SIZE OF SECTIONS

F or F' = 33	$\underline{S}$ or $\underline{S}'$ = 21
S or S' = 24	$\overline{M}$ or $\overline{M}'$ = 15
J or J' = 22	D_1, D'_1, D_2 or D'_2 = 9

(Note that it is necessary to have a large total enrollment in order to group students into sections of these sizes. If the program were to be started with only one section of 33 freshmen, the sections in following terms would diminish in accordance with the ratios shown in Table 1.)

4. Undergraduates and master's candidates take five courses in each term.
5. Doctor's candidates take the equivalent of five courses in each term (some actual courses plus thesis work).

The above assumptions are purely arbitrary and are not intended necessarily to represent optimum practice. The reader may use his own figures in the type of analysis which will follow.

Using these figures, the number of teachers needed for the various classes may be calculated. For example, the number of teachers needed for the first-term freshman students is $N_F = \frac{5F}{(33)(4)} = 0.0125C$. The figures for all classes are shown in Table 3.

Table 3

NUMBER OF TEACHERS NEEDED FOR EACH CLASS

$N_F = 0.0125C$	$N_F' = 0.01034C$
$N_S = 0.0127C$	$N_S' = 0.01167C$
$N_J = 0.01234C$	$N_J' = 0.0120C$
$N_{\underline{S}} = 0.01243C$	$N_{\underline{S}}' = 0.0122C$
$N_M = 0.00469C$	$N_M' = 0.00460C$
$N_D = 0.00313C$ (for D_1, D'_1, D_2)	$N_{D'_2} = 0.00308C$

The Research Program

One of the most important factors to be determined is the extent to which the physical plant of the institution is used for instruction and research. Arbitrarily, it has been assumed that a portion of the plant has been set aside for research and that this portion will be used by the following personnel: (a) full-time throughout the calendar year, faculty research workers equal in number to 35% of the maximum number of teachers needed at any time during the year; (b) full-time

in any term, 25% of the second-year graduate students enrolled in that term ($0.25D_1$ or $0.25D'_1$); (c) full-time in any term, all of the third-year graduate students enrolled in that term (D_2 or D'_2). Again arbitrarily, it has been assumed that the research space is adequate to accommodate a number of workers equal to $R = 0.04P$ where P is the maximum number of students which can be accommodated in the instructional facilities of the institution at any one time.

IV. OPERATIONAL INDICES

The Plant Capacity

Since primary interest is focussed on the size of the instructional facilities, most of the factors in this study will eventually be expressed in terms of P. It must be understood that P represents the maximum number of students that can be accommodated at *any one time*. It will be assumed that the enrollment cannot be permitted to exceed this figure even for a short time. It will also be assumed that the plant will be utilized to this maximum value during at least one term in the year when the schedule calls for the greatest enrollment. It is understood that P may vary somewhat with changes in schedule. If necessary, this variation can be taken into account in the final comparison of one system with another. However, with reasonably large enrollments, and with care in balancing the scheduling of one-term courses, the variation will not be great enough to alter any of the conclusions of this study.

Relative Use Factors

In order to compare one operating schedule with another it will be convenient to employ the "relative use factor". There are three such factors. The first, U_i, refers to the use of instructional facilities. The second, U_r, refers to the use of research facilities. The third, U_t, indicates the effectiveness with which the teaching staff is employed in instruction ($U_t = 1$ would mean that each teacher carries a full teaching load continuously throughout the year).

Relative Use Factor of Instructional Facilities

The relative use factor of instructional facilities, U_i, is the ratio of the sum of the weighted actual use factors to the weighted ideal use factor. The ideal use factor is the average use factor of all instructional facilities over one complete term (including registration and examination periods) with the maximum possible enrollment. This is weighted by 52 in order to cover all 52 weeks in a year. The actual use factor for any term is determined for the actual enrollment in that term and is weighted by the number of weeks in that term. The relative use factor is then the sum of the weighted actual use factors divided by the weighted ideal use factor. For example, assume that the

operating schedule calls for three terms of 16 weeks each plus four weeks of recess and vacation in a calendar year. Let U_{ai1}, U_{ai2}, U_{ai3}, U_{aiv} be the actual use factors for the first, second and third terms, and for the recess and vacation periods respectively. Let U_{ii} be the ideal use factor. Then the relative use factor will be

$$U_i = \frac{16\,U_{ai1} + 16\,U_{ai2} + 16\,U_{ai3} + 4\,U_{aiv}}{52\,U_{ii}}$$

It will simplify the determination of U_i to assume that the use factors of the instructional facilities are directly proportional to the enrollment (or to an equivalent enrollment in the recess and vacation period). Then if E_1, E_2 and E_3 represent the enrollment in each of the three terms, if E_V is the equivalent enrollment for the recess and vacation period, if W_1, W_2, W_3, W_V are the number of weeks in each of the periods, and if P is the maximum possible enrollment,

$$U_i = \frac{W_1 E_1 + W_2 E_2 + W_3 E_3 + W_V E_V}{52\,P}$$

This latter formula will be used throughout the analysis. (Different numbers of terms may be used in the numerator to analyze schedules which involve other than four parts in a year.)

Relative Use Factor of Research Facilities

The relative use factor of the research facilities may be obtained from the following formula where R_1, R_2 and R_3 are the numbers of research workers in each of the three terms, R_V is the number engaged on the average during the recess and vacation period, and R is the arbitrary standard number as defined previously. Again the numerator may be expanded or contracted if necessary.

$$U_r = \frac{W_1 R_1 + W_2 R_2 + W_3 R_3 + W_V R_V}{52\,R}$$

Relative Use Factor of Teaching Staff

The relative use factor of the teaching staff, which is a measure of the effectiveness with which the teachers are used for instruction, may be calculated from the following formula where N_1, N_2, N_3 and N_V are the teaching loads expressed as the numbers of equivalent full-time teachers needed for instruction in each of the three terms and the recess and vacation period. N is the optimum number of equivalent full-time teachers needed under the conditions of the most effective utilization at any time.

$$U_t = \frac{W_1 N_1 + W_2 N_2 + W_3 N_3 + W_V N_V}{52\ N}$$

It will be seen later that N_1, N_2, N_3, N_V and N may be expressed in terms of P, and that N = 0.0571 P. Throughout the analysis U_t will be calculated using this value of N.

Note that N_1, N_2, N_3 and N_V represent teaching loads in the various periods expressed as equivalent full-time persons. While the teaching load may vary from term to term, it will be assumed that the number of persons employed as teachers will remain constant throughout the three regular terms at a value equal to the maximum teaching load (N_m). In other words, it will be assumed in this study that the institution will engage enough teachers (N_m) to handle the maximum teaching load and that these persons may carry lighter loads in those terms when the total teaching load is below the maximum.

The work required of teachers during the recess and vacation period (represented by N_V) will be assumed to be unrelated to the degree-granting programs and will not be included in the degree cost, which will be calculated later. Principally, N_V represents summer school teaching in those schedules where summer school is possible. In most cases, N_V will be zero.

Number of Courses Required

To understand the true significance of the teaching load it is necessary to know not only how many students are to be taught but also how many different courses are to be offered at a given time. Obviously, the number of necessary courses will depend on the number of curricula which are presented. Since this study is concerned with a comparison of one schedule with another, any number of curricula may be used provided that this number be kept constant. Arbitrary assumptions regarding course offerings will be made as follows:

1. The institution offers five curricula; a, b, c, d, e.
2. All undergraduates and master's candidates take five courses each term. Doctoral candidates take three courses in each term of the second graduate year and one course in each term during the third graduate year.
3. All freshmen take the same courses.
4. There is no choice of elective courses.

The number of courses common to two or more curricula, the number of specialized courses, and the total number of courses required each term will be assumed to vary as shown in Table 4.

Table 4

NUMBER OF COURSES

Term	Common to 2 or more	For curriculum a	b	c	d	e	Total
F, F'	5	0	0	0	0	0	5
S, S'	5	2	2	1	1	1	12
J, J'	5	3	2	2	2	2	16
$\underline{S}$, $\underline{S}'$	3	4	4	3	3	3	20
$\overline{M}$, $\overline{M}'$	1	4	4	4	4	4	21
D_1, D_1'	0	3	3	3	3	3	15
D_2, D_2'	0	1	1	1	1	1	5

Plant Capacity Index

As the analysis proceeds it will become apparent that the number of courses required each term will vary with the operating schedule. Those schedules which require a large number of courses at a given time cannot be operated economically with a small enrollment. It will be useful to determine in each case the "plant capacity index" (P_m) defined as follows. Assume that each class of students starts with only one standard section of freshmen (33 students) in each curriculum and that this section diminishes each term in accordance with the ratios shown in Table 1. (With this small starting group it will be impossible to maintain economical section sizes at the graduate level.) Assume that equal groups of freshmen are admitted n times in a calendar year. Then in one calendar year nF freshmen will be admitted. This number can be related to the plant capacity by the formula $F = 0.330C$ where C can be expressed as a function of P, say kP. Hence, $F = 0.330kP$ and $P = \frac{F}{0.330k}$. If each freshman group is limited to one section of 33 students in one curriculum, then the plant capacity index is $P_m = \frac{33}{0.330k} = \frac{100}{k}$. The value of $k = \frac{C}{P}$ will vary with n and also with the form of the operating schedule.

The numerical value of P_m has limited intrinsic significance but it serves as a useful means of comparing one system with another. The larger the value of P_m, the larger the plant capacity must be in order to permit economical operation with the given schedule. Note that P_m is also a measure of the minimum enrollment needed for economical operation. A relation between P_m and the minimum economic enrollment per curriculum can be determined for a given institution on the basis of the conditions existing at that institution.

Cost of Instruction

A matter of great concern in this analysis is the relative cost of providing instruction with a given schedule. It will be convenient to express the total operating cost of instruction in each case in terms of the teaching salaries.

Some operating costs will change very little with a shift to year-around operation while others will change considerably. Table 5 shows the arbitrary assumptions which will be made regarding the major items of operating costs. (Auxiliary enterprises, extension services, and contract research are omitted from these calculations.) The reader can readily substitute figures which apply more directly to his own institution. The column headed "Present Standard Program" shows a typical distribution of costs in the usual two-semester year with a modest summer school program. The numbers in the column headed "Percent Increase" are the estimated increases which would occur in the various items in the shift to year-around operation. The last column shows the distribution of costs in the year-around program. The bottom line in the table indicates that in the present standard two-semester year the total annual operating cost is 2.48 times the teaching salaries. With year-around operation the total annual operating cost is 2.33 times the teaching salaries. The distributions shown in Table 5 are assumed to hold when the plant is operated at maximum capacity during regular terms when students are attending classes. Variations which occur from term to term with changes in plant load will be ignored in this study.

Table 5

ASSUMPTIONS REGARDING OPERATING COSTS

Item	Present Standard Program	Percent Increase	Year-Around Program
Teaching Salaries	40.3%	30	42.9%
Other Operating Costs	59.7%	17	57.1%
Total	100.0%	22	100.0%
$q = \frac{\text{Total operating cost}}{\text{Teaching Salaries}}$	2.48		2.33

Since much of the cost analysis depends on the amount assigned to teaching salaries, it is necessary to explain the assumptions which lead to the conclusion that teaching salaries will rise 30% when shifting from the present to the year-around program.

First it is assumed that the average teacher in the present two-semester year receives an academic-year salary and is required to devote 37 weeks to his teaching duties. Second, it is assumed that on

the year-around program the average teacher will be paid a calendar-year salary for spending 48 weeks on his teaching duties. The 30% increase in time is compensated for by a similar increase in salary. If all teachers work full-time throughout each term, the total teaching salaries will rise 30%. The reader who wishes to consider the effect of deviations from full-time employment or who wishes to use ratios different from those shown above can readily modify the numerical values which will be derived later in this paper.

Let the total annual operating cost be Q, and let the average annual teaching salary be T. Assume that the number of persons employed as teachers remains constant throughout all of the regular terms when the students are in session at a value N_m (the equivalent full-time teachers needed in the term when the teaching load is greatest). If the ratio of the total operating cost to the total teaching salaries is q, then $Q = qTN_m$.

Degree Cost Index

A useful indicator of the over-all cost of an educational program may be obtained by dividing the total annual operating cost by the number of degrees granted in a year. Call this ratio the "degree cost index" G_c. For simplicity in this study, the total number of bachelor's, master's and doctor's degrees will be used for this calculation. Thus the total number of degrees granted in a year is $G = G_B + G_M + G_D$. Hence, $G_c = \frac{Q}{G}$. Since both Q and G may be expressed in terms of P, the degree cost index can be obtained as a function of q and T for each operating schedule. Thus $G_c = \frac{qTN_m}{G_B+G_M+G_D} = \frac{qTk''P}{k'''P} = ak'T$.

If T_a is the academic-year salary paid for the present standard two-semester year, and if the ratios of Table 5 are applied, the expressions for G_c become:

present standard, $G_c = 2.48k'T_a$
year-around, $G_c = 2.33k'(1.30T_a) = 3.03k'T_a$

The numerical value of G_c is an indication of the minimum cost per degree under the following conditions: (a) with the physical plant operating at maximum capacity during at least one term, (b) with full sections of the sizes shown in Table 2, (c) with entering classes of the same size (unless otherwise indicated), and (d) with the number of persons employed as teachers equal to the number of equivalent full-time teachers needed during the term when the teaching load is greatest. The reader can modify section size or student-teacher ratio. (Note, for example, that the assumptions made in this paper lead to a student-teacher ratio of 17.5 in the most efficient schedules. The reader may wish to employ a smaller ratio in order to permit lighter teaching

loads in at least one term each year. With no summer recess other than the minimum required for a vacation, the year-around schedule allows the teacher no uninterrupted period for the preparation of new course material.) For the purposes of this bulletin the relative rather than the absolute values of G_C are of major significance.

V. ANALYSIS OF PROGRAMS

Program Notation

The following notation will be used to designate the operating schedules which are to be compared. With the exception of Program S, all involve year-around operation.

Program S: The present standard two-semester year. Students are admitted once a year. Students are in class for two terms and are off during the summer.

Program A2: The letter A indicates that students are in class for two semesters and off for one. The number 2 indicates that students are admitted twice a year. All entering classes are the same size.

Program A3: Similar to A2 except that students are admitted three times a year.

Program B1: The letter B indicates that students are in class continuously during three terms a year. The number 1 indicates that students are admitted once a year.

Program B2: Similar to B1 except that students are admitted twice a year. All entering classes are the same size.

Program B3: Similar to B1 except that students are admitted three times a year. All entering classes are the same size.

Program C3: The letter C indicates that the undergraduates follow a "cooperative" type of schedule. The freshmen are in class for two terms and off one term. After the freshman year, the undergraduates alternate — one term in class, one term off. Graduate students are in class two terms, off one term. The number 3 indicates that students are admitted three times a year. All entering classes are the same size.

Program A3': Similar to Program A3 except that classes admitted in the first term are twice as large as those admitted in the second and third terms.

Analysis of Program S

Let us turn now to a detailed analysis of various specific operating schedules. Since all schedules are to be compared with the present standard (Program S), the latter will be considered first.

Program S — Assume that students are admitted once a year and

that all entering classes are the same size. Let the students be in class for two consecutive terms and be on vacation during the summer months. Assume that the system has been in operation long enough to have filled all classes in the steady state. The first term enrollment will then consist of the following groups: F S J $\underline{S}$ M D_1 D_2 = 1.076C (applying ratios of Table 1). The second term enrollment will be F' S' J' $\underline{S}$' M' D_1' D_2' = 0.9879C. There will be no regular classes during the summer. (Summer activities will be considered later.) The larger enrollment occurs in the first term. Assume that the number of students enrolled during the first term (1.076C) is made equal to the maximum plant capacity P. Then 1.076C = P, or $C = \frac{P}{1.076}$.

The teaching load may be determined by applying the factors from Table 3. Thus, to serve the students enrolled during the first term, the number of equivalent full-time teachers needed is $N_F + N_S + N_J + N_S + N_M + N_{D_1} + N_{D_2} = 0.0610C = 0.0566P$. The teaching load of the second term is $N_{F'} + N_{S'} + N_{J'} + N_{S'} + N_{M'} + N_{D_1'} + N_{D_2'} = 0.0530P$.

To calculate the research load, or the number of equivalent full-time research workers who will need facilities each term, assume that the number of persons employed for teaching and research remains (throughout the time when students are in session) equal to the number needed in the term when the teaching load is greatest. In Program S the maximum number of teachers (0.0566P) is needed in the first term. According to the assumptions made earlier, a faculty research staff equal to 35% of this number of teachers will be active during each term when the students are in session. To this fixed number must be added in each term 25% of the D_1 and D_1' students plus 100% of the D_2 and D_2' students. Thus in the first term the research load is $0.35(0.0566P) + 0.25D_1 + D_2 = 0.35(0.0566P) + 0.25(0.0169C) + 0.0169C = 0.35(0.0566P) + 0.25(0.0169)\left[\frac{P}{1.076}\right] + (0.0169)\left[\frac{P}{1.076}\right] = 0.0394P$. Since the normal research load was arbitrarily defined as R = 0.040P, the first-term research load is $0.0394P = 0.0394\left[\frac{R}{0.040}\right] = 0.985R$. In similar fashion the research load of the second term is found to be 0.979R.

The number of different courses required in each term can be found by using the figures of Table 4. Thus for the first term, students F S J $\underline{S}$ M D_1 D_2 require 5+12+16+20+21+15+5 = 94 courses. The same number holds for the second term.

The plant capacity index for Program S is $P_m = \frac{100}{k}$ where $k = \frac{C}{P} = \frac{1}{1.076}$. Thus $P_m = 107.6$. (Note that it would take a total of 133 students to fill one complete section of every undergraduate and graduate course in one curriculum in the first term of Program S. The value of P_m is the number of students in one curriculum with one full section

in each undergraduate course, and with graduate sections in the proportions shown in Table 1.)

The enrollment pattern of Program S shows one section of $\underline{S}'$, one section of M', and one section of D_2' each year. Assuming that the enrollment is well above the plant capacity index, the annual numbers of degrees granted at the bachelor's, master's and doctor's levels are $G_B = 0.169C = 0.1571P$, $G_M = 0.0393C = 0.0365P$, $G_D = 0.0132C = 0.0123P$. Hence $G = G_B+G_M+G_D = 0.2059P$.

The degree cost index, G_c, for Program S will be calculated on the basis of the work performed during the terms when the students are in regular session. Summer activities outside the regular academic year will not be included. The total operating cost is $Q = qTN_m = qT(0.0566P)$. Thus,

$$G_c = \frac{Q}{G} = \frac{0.0566qTP}{0.2059P} = 0.276\,qT = 0.276(2.48)T_a$$

$$G_c = 0.685T_a$$

The relative use factor of the instructional facilities, U_i, for Program S will be calculated by assuming that each term is of 17 weeks duration and that the Christmas and spring recesses plus the summer activities (including orientation of freshmen) extend over 18 weeks. A study of a representative sample of five institutions shows that all of the recess and summer activities of the average university may be equated to an equivalent enrollment of $E_3 = 0.3P$ students. Thus,

$$U_i = \frac{W_1 E_1+W_2 E_2+W_V E_V}{52P} = \frac{17(P) + 17(0.917P) + 18(0.3P)}{52P}$$

$$U_i = 0.730$$

In order to obtain the relative use factor of the research facilities in Program S it will be assumed arbitrarily that the faculty research workers who are active during the academic year will work on research during the Christmas and spring recesses and for all but four weeks during the summer, and that graduate students equal in number to one-half of the D_2 enrollment will work on research for the same period. This assumption leads to an average summer research load of 0.54R. Thus,

$$U_r = \frac{W_1 R_1+W_2 R_2+W_V R_V}{52R} = \frac{17(0.985R) + 17(0.979R) + 18(0.54R)}{52R}$$

$$U_r = 0.830$$

The relative use factor of the teaching staff, U_t, will be based on the use made of the staff for teaching duties during the regular academic year plus an assumed use of 0.1 of the maximum number of teachers on the average throughout the recesses and the summer.

Thus

$$U_t = \frac{W_1 N_1 + W_2 N_2 + W_V N_V}{52N} = \frac{17(0.0566P) + 17(0.0530P) + 18(0.1)(0.0566P)}{52(0.0571P)}$$

$$U_t = 0.661$$

The pertinent information on Program S is tabulated on page 19. The zeros for summer students and summer courses indicate that students are not required to attend classes during the summer in order to take the courses which form a part of the normal academic year. Special summer courses such as Surveying Camp and repeat summer session courses are included in the figure for summer enrollment.

Analysis of Year-Around Programs

Calculations similar to those for Program S can be made to determine the various factors which describe the year-around operations. When dealing with Programs A, B and C it will be assumed that during a total of four weeks in the calendar year students, teachers, and research workers will be on vacation. Thus the summary sheets will show zero in the "Vacation" column for students, teaching load, research load, and number of courses. However, it will also be assumed that some of the physical facilities will be used during the vacation period for functions such as conferences and symposia which are not related to the regular curricula. The average vacation-time load of such activities will be taken as equivalent to an enrollment of 0.3P.

The data for Programs A, B and C are summarized on pages 20-26.

Quarter Systems

Thus far this analysis has contained descriptions of systems involving two terms per academic year. The study would not be complete without reference to programs which require three terms per academic year. A schedule presently in use in a number of colleges divides the calendar year into four 11.5-week terms (or quarters) plus six weeks of recess and summer activities. Using this schedule, the following four programs will be considered.

Program Q1: Students are admitted once a year. Students are in class for three terms and off for one term.

Program Q4: Similar to Q1 except that students are admitted four times a year. All entering classes are the same size.

Program CQ1: A "cooperative" system in which students are admitted once a year and divided into two equal groups which alternate between college and industry in the upper-class undergraduate years.

Program CQ4: A "cooperative" system in which equal classes are admitted four times a year. Each class consists of one group of students which alternates between college and industry in the upperclass undergraduate years.

Modifications of the assumptions made for the two-term analyses may be made for the three-term academic year. Thus if F, F′ and F″ represent freshmen in the first, second and third terms, the corresponding ratios will be F = 0.330C, F′ = 0.301C, and F″ = 0.273C. In each case the second-term ratio is taken as midway between the two ratios shown in Table 1. In the quarter systems the value of F is the same as that of F in Table 1, while the value of F″ is the same as that of F′ in Table 1. Similar modifications are made for the teaching staff figures of Table 3.

It will be assumed that a person who teaches four 11.5-week terms will be required to be on the campus for a total of 48 weeks per year (46 weeks of classes, examinations and registration plus two weeks for such things as freshmen orientation and recess periods.) A faculty member who teaches three 11.5-week terms will spend 37 weeks on campus (34.5 weeks of classes, examinations and registration plus 2.5 weeks for other activities). The ratios of Table 5 will be assumed to hold approximately for the quarter system in all but one case. Thus for Program Q1, the value of q will be 2.48, while for Programs Q4 and CQ4, q will be 2.33. In the case of Program CQ1 an intermediate value q = 2.40 will be used. Furthermore, in this case it will be assumed that only one third of N_m faculty members will teach for four terms per year. The others will teach for three terms. In Program Q1 all faculty members teach three terms per year, while in Programs Q4 and CQ4 all teach four terms per year. The teaching load during the six-week summer and recess period will be taken as 20% of N_m.

The data for Programs Q and CQ are summarized on pages 27-30.

Program S (Present Standard)

Admit: Once a year. All entering classes same size.

Time to reach B.S. : 3-2/3 years.

SCHEDULE: Two 17-week terms per calendar year. Students in class two terms, off summer.

Year	1			2			3			4			5			6			7		
Students	F	F′		S	S′		J	J′		$\underline{S}$	$\underline{S}'$		M	M′		D_1	D_1'		D_2	D_2'	

DISTRIBUTION OVER YEAR

	First Term	Second Term	Recesses & Summer
Students	F S J $\underline{S}$ M D_1 D_2	F′ S′ J′ $\underline{S}'$ M′ D_1' D_2'	0
Enrollment	P = 1.076C	0.917P	equiv. 0.3P
Teaching Load	0.0566P	0.053P	equiv. 0.0056P
Research Load	0.985R	0.979R	0.540R
Number of Courses	94	94	0

Graduates per Year

B.S., $G_B = 0.1571P$ Ph. D., $G_D = 0.0123P$

M.S., $G_M = 0.0365P$ Total, $G = 0.2059P$

Plant Capacity Index: $P_m = 108$

Degree Cost Index: $G_c = 0.682T_a$

Relative Use Factor, Instructional Facilities: $U_i = 0.730$

Relative Use Factor, Research Facilities: $U_r = 0.830$

Relative Use Factor, Teaching Staff: $U_t = 0.661$

Program A2

Admit: Twice a year. All entering classes same size.

Time to reach B.S. : 3-2/3 years

SCHEDULE: Three 16-week terms per calendar year. Students in class two terms, off one term.

Year	1			2			3			4			5			6			7		
Students	F	F′		S	S′		J	J′		$\underline{S}$	$\underline{S}'$		M	M′		D_1	D_1'		D_2	D_2'	
Students		F	F′		S	S′		J	J′		$\underline{S}$	$\underline{S}'$		M	M′		D_1	D_1'		D_2	D_2'

DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Vacation
Students	F S J $\underline{S}$ M D_1 D_2	F F′ S S′ J J′ $\underline{S}$ $\underline{S}'$ M M′ D_1 D_1' D_2 D_2'	F′ S′ J′ $\underline{S}'$ M′ D_1' D_2'	0
Enrollment	0.521P	P = 2.064C	0.479P	equiv. 0.3P
Teaching Load	0.0295P	0.0571P	0.0276P	0
Research Load	0.750R	R	0.750R	0
No. of Courses	94	188	94	0

Graduates per Year

B.S., $G_B = 0.1638P$ Ph. D., $G_D = 0.0127P$

M.S., $G_M = 0.0380P$ Total, $G = 0.2145P$

Plant Capacity Index: $P_m = 206$

Degree Cost Index: $G_c = 0.806T_a$

Relative Use Factor, Instructional Facilities: $U_i = 0.639$

Relative Use Factor, Research Facilities: $U_r = 0.770$

Relative Use Factor, Teaching Staff: $U_t = 0.615$

Program A3

Admit: Three times a year. All entering classes same size.

Time to reach B.S. : 3-2/3 years.

SCHEDULE: Three 16-week terms per calendar year. Students in class two terms, off one term.

Year	1			2			3			4			5			6			7			8		
Students	F	F′		S	S′		J	J′		$\underline{S}$	$\underline{S}'$		M	M′		D_1	D_1'		D_2	D_2'				
Students		F	F′		S	S′		J	J′		$\underline{S}$	$\underline{S}'$		M	M′		D_1	D_1'		D_2	D_2'			
Students			F	F′		S	S′		J	J′		$\underline{S}$	$\underline{S}'$		M	M′		D_1	D_1'		D_2	D_2'			

DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Vacation
Students	F F′ S S′ J J′ $\underline{S}$ $\underline{S}'$ M M′ D_1 D_1' D_2 $\overline{D_2'}$	F F′ S S′ J J′ $\underline{S}$ $\underline{S}'$ M M′ D_1 D_1' D_2 $\overline{D_2'}$	F F′ S S′ J J′ $\underline{S}$ $\underline{S}'$ M M′ D_1 D_1' D_2 $\overline{D_2'}$	0
Enrollment	P = 2.064C	P	P	equiv. 0.3P
Teaching Load	0.0571P	0.0571P	0.0571P	0
Research Load	R	R	R	0
No. of Courses	188	188	188	0

Graduates per Year

B.S., $G_B = 0.2455P$ Ph. D., $G_D = 0.0192P$

M.S., $G_M = 0.0570P$ Total, $G = 0.3217P$

Plant Capacity Index: $P_m = 206$

Degree Cost Index: $G_c = 0.539T_a$

Relative Use Factor, Instructional Facilities: $U_i = 0.946$

Relative Use Factor, Research Facilities: $U_r = 0.923$

Relative Use Factor, Teaching Staff: $U_t = 0.923$

Program B1

Admit: Once a year (freshmen, first term; masters, third term; doctors, second term).

Time to reach B.S. : 2-2/3 years.

SCHEDULE: Three 16-week terms per calendar year.
Students in class continuously three terms per year.

Year	1			2			3			4			5		
Students	F	F′	S	S′	J	J′	$\underline{S}$	$\underline{S}'$	M	M′	D_1	D_1'	D_2	D_2'	

DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Vacation
Students	F S′ $\underline{S}$ M′ D_2	F′ J $\underline{S}'$ D_1 D_2'	S J′ M D_1'	0
Enrollment	P = 0.8213C	0.886P	0.626P	equiv. 0.3P
Teaching Load	0.05396P	0.04991P	0.03959P	0
Research Load	0.985R	1.1R	0.985R	0
No. of Courses	63	61	64	0

Graduates per Year

B.S., G_B = 0.2060P Ph. D., G_D = 0.0161P

M.S., G_M = 0.0479P Total, G = 0.2700P

Plant Capacity Index: P_m = 82

Degree Cost Index: $G_c = 0.606T_a$

Relative Use Factor, Instructional Facilities: U_i = 0.794

Relative Use Factor, Research Facilities: U_r = 0.945

Relative Use Factor, Teaching Staff: U_t = 0.774

Program B2

Admit: Twice a year (freshmen, first and second terms; masters, first and third terms; doctors, second and third terms). All entering classes same size.

Time to reach B.S. : 2-2/3 years.

SCHEDULE: Three 16-week terms per calendar year.
Students in class continuously three terms per year.

Year	1			2			3			4			5		
Students	F	F′	S	S′	J	J′	$\underline{S}$	$\underline{S}'$	M	M′	D_1	D_1'	D_2	D_2'	
Students		F	F′	S	S′	J	J′	$\underline{S}$	$\underline{S}'$	M	M′	D_1	D_1'	D_2	D_2'

DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Vacation
Students	F S S′ J′ $\underline{S}$ M M′ D_1' $\overline{D}_2$	F F′ S′ J $\underline{S}$ $\underline{S}'$ M′ D_1 D_2 $\overline{D}_2'$	F′ S J J′ $\underline{S}'$ M D_1 D_1' $\overline{D}_2'$	0
Enrollment	0.861P	P = 1.550C	0.802P	equiv. 0.3P
Teaching Load	0.0496P	0.0551P	0.0475P	0
Research Load	0.818R	1.09R	0.885R	0
No. of Courses	127	124	125	0

Graduates per Year

B.S., $G_B = 0.2180P$ Ph. D., $G_D = 0.0170P$

M.S., $G_M = 0.0507P$ Total, $G = 0.2857P$

Plant Capacity Index: $P_m = 155$

Degree Cost Index: $G_c = 0.585T_a$

Relative Use Factor, Instructional Facilities: $U_i = 0.842$

Relative Use Factor, Research Facilities: $U_r = 0.860$

Relative Use Factor, Teaching Staff: $U_t = 0.820$

Program B3

Admit: Three times a year. All entering classes same size.

Time to reach B.S. : 2-2/3 years.

SCHEDULE: Three 16-week terms per calendar year.
Students in class continuously three terms per year.

Year	1			2			3			4			5			6		
Students	F	F′	S	S′	J	J′	$\underline{S}$	$\underline{S}'$	M	M′	D_1	D_1'	D_2	D_2'				
Students		F	F′	S	S′	J	J′	$\underline{S}$	$\underline{S}'$	M	M′	D_1	D_1'	D_2	D_2'			
Students			F	F′	S	S′	J	J′	$\underline{S}$	$\underline{S}'$	M	M′	D_1	D_1'	D_2	D_2'		

DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Vacation
Students	F F′ S S′ J J′ S S′ M M′ D_1 D_1' D_2 $\overline{D_2'}$	F F′ S S′ J J′ S S′ M M′ D_1 D_1' D_2 $\overline{D_2'}$	F F′ S S′ J J′ S S′ M M′ D_1 D_1' D_2 D_2'	0
Enrollment	P = 2.064C	P	P	equiv. 0.3P
Teaching Load	0.0571P	0.0571P	0.0571P	0
Research Load	R	R	R	0
No. of Courses	188	188	188	0

Graduates per Year

B.S., $G_B = 0.2455P$ Ph. D., $G_D = 0.0192P$

M.S., $G_M = 0.0570P$ Total, $G = 0.3217P$

Plant Capacity Index: $P_m = 206$

Degree Cost Index: $G_c = 0.539T_a$

Relative Use Factor, Instructional Facilities: $U_i = 0.946$

Relative Use Factor, Research Facilities: $U_r = 0.923$

Relative Use Factor, Teaching Staff: $U_t = 0.923$

Program C3

Admit: Three times a year. All entering classes same size.

Time to reach B.S. : 4-2/3 years.

SCHEDULE: Three 16-week terms per calendar year. Undergraduates on "cooperative" schedule. Graduates in class two terms, off one term.

Year	1			2			3			4			5			6			7			8			9		
Students	F	F′		S		S′		J		J′		$\underline{S}$		$\underline{S}'$		M	M′		D_1	D_1'		D_2	D_2'				
Students		F	F′		S		S′		J		J′		$\underline{S}$		$\underline{S}'$		M	M′		D_1	D_1'		D_2	D_2'			
Students			F	F′		S		S′		J		J′		$\underline{S}$		$\underline{S}'$		M	M′		D_1	D_1'		D_2	D_2'			

DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Vacation
Students	F F′ S S′ J J′ $\underline{S}$ $\underline{S}'$ M M′ D_1 D_1' D_2 $\underline{D_2'}$	F F′ S S′ J J′ $\underline{S}$ $\underline{S}'$ M M′ D_1 D_1' D_2 $\underline{D_2'}$	F F′ S S′ J J′ $\underline{S}$ $\underline{S}'$ M M′ D_1 D_1' D_2 $\underline{D_2'}$	0
Enrollment	P = 2.064C	P	P	equiv. 0.3P
Teaching Load	0.0571P	0.0571P	0.0571P	0
Research Load	R	R	R	0
No. of Courses	188	188	188	0

Graduates per Year

B.S., $G_B = 0.2455P$ Ph. D., $G_D = 0.0192P$

M.S., $G_M = 0.0570P$ Total, $G = 0.3217P$

Plant Capacity Index: $P_m = 206$

Degree Cost Index: $G_c = 0.539T_a$

Relative Use Factor, Instructional Facilities: $U_i = 0.946$

Relative Use Factor, Research Facilities: $U_r = 0.923$

Relative Use Factor, Teaching Staff: $U_t = 0.923$

Program A3′

Admit: Three times a year. First term admissions twice as large as admissions of second and third terms.

Time to reach B.S. : 3-2/3 years.

SCHEDULE: Three 16-week terms per calendar year. Students in class two terms, off one term.

Year	1			2			3			4			5			6			7			8		
Students	2F	2F′		2S	2S′		2J	2J′		2$\underline{S}$	2$\underline{S}$′		2M	2M′		2D_1	2D_1'		2D_2	2D_2'				
Students		F	F′		S	S′		J	J′		$\underline{S}$	$\underline{S}$′		M	M′		D_1	D_1'		D_2	D_2'			
Students			F	F′		S	S′		J	J′		$\underline{S}$	$\underline{S}$′		M	M′		D_1	D_1'		D_2	D_2'			

DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Vacation
Students	F F F′ S S S′ J J J′ $\underline{S}$ $\underline{S}$ $\underline{S}$′ M M $\overline{M'}$ D_1 D_1 D_1' D_2 D_2 D_2'	F F′ F′ S S′ S′ J J′ J′ $\underline{S}$ $\underline{S}$′ $\underline{S}$′ M M′ $\overline{M'}$ D_1 D_1' D_1' D_2 D_2' D_2'	F F′ S S′ J J′ $\underline{S}$ $\underline{S}$′ M M′ D_1 D_1' D_2 $\overline{D_2'}$	0
Enrollment	P = 3.139C	0.972P	0.658P	equiv. 0.3P
Teaching Load	0.0571P	0.0558P	0.0376P	0
Reseach Load	R	R	0.835R	0
No. of Courses	188	188	188	0

Graduates per Year

B.S., $G_B = 0.2158P$ Ph. D., $G_D = 0.0168P$

M.S., $G_M = 0.0501P$ Total, $G = 0.2827P$

Plant Capacity Index: $P_m = 314$

Degree Cost Index: $G_c = 0.612T_a$

Relative Use Factor, Instructional Facilities: $U_i = 0.831$

Relative Use Factor, Research Facilities: $U_r = 0.872$

Relative Use Factor, Teaching Staff: $U_t = 0.810$

Program Q1

Admit: Once a year. All entering classes same size.

Time to reach B.S. : 3-3/4 years.

SCHEDULE: Four 11.5-week terms per calendar year plus six weeks of recess and summer activities. Students in class three terms, off one term.

Year	1				2				3				4				5				6				7			
Students	F	F′	F″		S	S′	S″		J	J′	J″		$\underline{S}$	$\underline{S}'$	$\underline{S}''$		M	M′	M″		D_1	D_1'	D_1''		D_2	D_2'	D_2''	

DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Fourth Term	Recesses & Summer
Students	F S J $\underline{S}$ M D_1 D_2	F′ S′ J′ $\underline{S}'$ M′ D_1' D_2'	F″ S″ J″ $\underline{S}''$ M″ D_1'' D_2''	0	0
Enrollment	P = 1.076C	0.960P	0.918C	equiv. 0.33P	equiv. 0.33P
Teaching Load	0.0566P	0.0546P	0.0530P	0	equiv. 0.011P
Research Load	0.986R	0.979R	0.979R	0.691R	0.230R
No. of Courses	94	94	94	0	0

Graduates per Year

B.S., $G_B = 0.1571P$ Ph. D., $G_D = 0.0123P$

M.S., $G_M = 0.0365P$ Total, $G = 0.2059P$

Plant Capacity Index: $P_m = 108$

Degree Cost Index: $G_c = 0.682T_a$

Relative Use Factor, Instructional Facilities: $U_i = 0.745$

Relative Use Factor, Research Facilities: $U_r = 0.831$

Relative Use Factor, Teaching Staff: $U_t = 0.648$

Program Q4

Admit: Four times a year. All entering classes same size.

Time to reach B.S. : 3-3/4 years.

SCHEDULE: Four 11.5-week terms per calendar year plus six weeks of recess and summer activities. Students in class three terms, off one term.

Year	1				2				3				4				5				6				7				8			
Students	F	F′	F″		S	S′	S″		J	J′	J″		$\underline{S}$	$\underline{S}'$	$\underline{S}''$		M	M′	M″		D_1	D_1'	D_1''		D_2	D_2'	D_2''					
Students		F	F′	F″		S	S′	S″		J	J′	J″		$\underline{S}$	$\underline{S}'$	$\underline{S}''$		M	M′	M″		D_1	D_1'	D_1''		D_2	D_2'	D_2''				
Students			F	F′	F″		S	S′	S″		J	J′	J″		$\underline{S}$	$\underline{S}'$	$\underline{S}''$		M	M′	M″		D_1	D_1'	D_1''		D_2	D_2'	D_2''			
Students				F	F′	F″		S	S′	S″		J	J′	J″		$\underline{S}$	$\underline{S}'$	$\underline{S}''$		M	M′	M″		D_1	D_1'	D_1''		D_2	D_2'	D_2''		

DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Fourth Term	Recesses & Summer
Students	F F′ F″ S S′ S″ J J′ J″ $\underline{S}$ $\underline{S}'$ $\underline{S}''$ M M′ M″ $\overline{D_1}$ $\overline{D_1'}$ D_1'' D_2 D_2' D_2''	– (Same)	– (Same)	– (Same)	0
Enrollment	P = 3.095C	P	P	P	equiv. 0.33P
Teaching Load	0.0571P	0.0571P	0.0571P	0.0571P	equiv. 0.011P
Research Load	R	R	R	R	0.23R
No. of Courses	282	282	282	282	0

Graduates per Year

B.S., G_B = 0.2180P Ph. D., G_D = 0.0171P

M.S., G_M = 0.0508P Total, G = 0.2859P

Plant Capacity Index: P_m = 310

Degree Cost Index: $G_c = 0.605T_a$

Relative Use Factor, Instructional Facilities: U_i = 0.923

Relative Use Factor, Research Facilities: U_r = 0.910

Relative Use Factor, Teaching Staff: U_t = 0.909

Program CQ1
(Present Cooperative Quarter)

Admit: Once a year (two equal starting sections). All entering classes same size.

Time to reach B.S. : 4-3/4 years.

SCHEDULE: Four 11.5-week terms per calendar year plus six weeks of recess and summer activities. Undergraduates on "cooperative" schedule. Graduates in class three terms, off one term.

Year	1	2	3	4	5	6	7	8
Sect. 1	F F′ F″	S S′ S″	J J′	J″ S	S′ S″	M M′ M″	D_1 D_1' D_1''	D_2 D_2' D_2''
Sect. 2	F F′ F″	S S′ S″	J J′	J″ S	S′ S″	M M′ M″	D_1 D_1' D_1''	D_2 D_2' D_2''

DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Fourth Term	Recesses & Summer
Students	F F S S J J″ S′ M M $\overline{D}_1$ D_1 D_2 D_2	F′ F′ S′ S′ J J″ S′ M′ M′ D_1' D_1' D_2' D_2'	F″ F″ S″ J′ S S″ S″ M″ M″ D_1'' D_1'' D_2'' D_2''	S″ J′ S	0
Enrollment	P = 1.935C	0.959P	0.906P	0.334P	equiv. 0.33P
Teaching Load	0.0563P	0.0546P	0.0532P	0.0187P	equiv. 0.011P
Research Load	1.04R	1.04R	1.03R	0.711R	0.237R
No. of Courses	110	110	114	48	0

Graduates per Year

B.S., $G_B = 0.1746P$ Ph. D., $G_D = 0.0136P$

M.S., $G_M = 0.0406P$ Total, $G = 0.2288P$

Plant Capacity Index: $P_m = 194$

Degree Cost Index: $G_c = 0.650T_a$

Relative Use Factor, Instructional Facilities: $U_i = 0.746$

Relative Use Factor, Research Facilities: $U_r = 0.872$

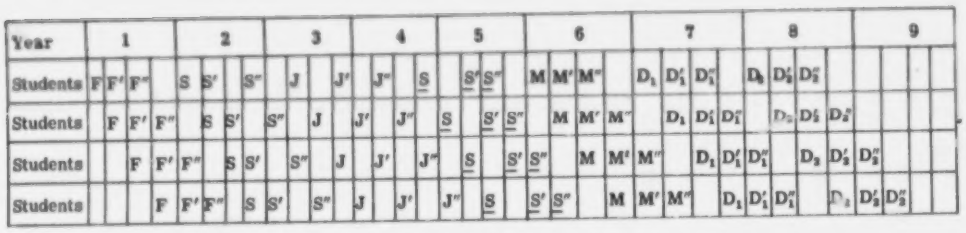
Relative Use Factor, Teaching Staff: $U_t = 0.730$

Program CQ4

Admit: Four times a year (one section in each class). All entering sections same size.

Time to reach B.S. : 4-3/4 years.

SCHEDULE: Four 11.5-week terms per calendar year plus six weeks of recess and summer activities. Undergraduates on "cooperative" schedule. Graduates in class three terms, off one term.



DISTRIBUTION OVER YEAR

	First Term	Second Term	Third Term	Fourth Term	Recesses & Summer
Students	F F′ F″ S S′ S″ J J′ J″ S S′ S″ M M′ M″ $\overline{D}_1$ $\overline{D}'_1$ D''_1 D_2 D'_2 D''_2	F F′ F″ S S′ S″ J J′ S S′ S″ M M′ M″ $\overline{D}_1$ $\overline{D}'_1$ D''_1 D_2 D'_2 D''_2	(Same)	(Same)	0
Enrollment	P = 3.095C	P	P	P	equiv. 0.33P
Teaching Load	0.0571P	0.0571P	0.0571P	0.0571P	equiv. 0.011P
Research Load	R	R	R	R	0.23R
No. of Courses	282	282	282	282	0

Graduates per Year

B.S., G_B = 0.2180P Ph. D., G_D = 0.0171P

M.S., G_M = 0.0508P Total, G = 0.2859P

Plant Capacity Index: P_m = 310

Degree Cost Index: $G_c = 0.605T_a$

Relative Use Factor, Instructional Facilities: U_i = 0.923

Relative Use Factor, Research Facilities: U_r = 0.910

Relative Use Factor, Teaching Staff: U_t = 0.909

VI. COMPARISONS AMONG PROGRAMS

The important characteristics of the various programs are shown in Table 6. For ready identification, the maximum and minimum values of critical factors are underlined.

Table 6

COMPARISON OF PROGRAM CHARACTERISTICS

Program	S	A2	A3	B1	B2	B3
G	0.206P	0.214P	0.322P	0.270P	0.286P	0.322P
P_m	108	206	206	82	155	206
G_c	$0.682T_a$	$0.806T_a$	$0.539T_a$	$0.606T_a$	$0.585T_a$	$0.539T_a$
U_i	0.730	0.639	0.946	0.794	0.842	0.946
U_r	0.830	0.770	0.923	0.945	0.860	0.923
U_t	0.661	0.615	0.923	0.774	0.820	0.923

Program	C3	A3'	Q1	Q4	CQ1	CQ4
G	0.322P	0.283P	0.206P	0.286P	0.229P	0.286P
P_m	206	314	108	210	194	310
G_c	$0.539T_a$	$0.612T_a$	$0.682T_a$	$0.605T_a$	$0.650T_a$	$0.605T_a$
U_i	0.946	0.831	0.745	0.923	0.746	0.923
U_r	0.923	0.872	0.831	0.910	0.872	0.910
U_t	0.923	0.810	0.648	0.909	0.730	0.909

It is apparent from the table that the lowest degree cost index and the highest relative use factors are attained when the enrollment is evenly distributed throughout the year. This even distribution requires (1) that students be admitted each term, and (2) that all entering classes be the same size. As long as these two conditions are met, the type of program is not significant.

To illustrate this point, consider Programs A3, B3 and C3. In A3, the student is in class two terms and off one, just as he is in the present standard Program S. The time required to reach the B.S. degree is 3-2/3 years as it is in Program S. In B3, the student is in class continuously, reaching the B.S. degree in 2-2/3 years. In C3, which is of the cooperative type, the student requires 4-2/3 years to reach the B.S. degree. However, the degree cost index and the various use factors are the same in all three programs. On the other hand, in A3' where the entering classes are not the same size, the cost index is higher and

the relative use factors are lower than in A3 despite the similarity in schedule for the individual student.

The figures for Program A2 show that year-around operation without even distribution of the enrollment may be more expensive and less efficient than the present Program S.

There is no significant difference in cost or efficiency between Programs S and Q1. The present cooperative quarter system CQ1 is seen to be only slightly more efficient and less expensive than Program S. However, when students are admitted four times a year, and when all entering classes are kept the same size (Programs Q4 and CQ4), the efficiency of the quarter system approaches that of Programs A3, B3 and C3. If the total length of the four terms in Programs Q4 and CQ4 were made equal to the total length of the three terms in Programs A3, P3 and C3, there would be no significant differences among the programs as regards the cost index and use factors. However, the plant capacity index for Programs Q4 and CQ4 is considerably higher than that for Programs A3, B3 and C3. This means that the advantages of Programs Q4 and CQ4 over Program S could be attained only with large enrollments. Furthermore, the number of graduates per year is smaller with Programs Q4 and CQ4 than with Programs A3, B3 and C3.

The reader may profitably make a detailed study of the relative merits of all of the programs which have been discussed. Many other possible schedules can also be analyzed by the techniques which have been developed. For example, one might consider schedules which involve less formal instruction and more independent student work, such as a quarter system in which the student is in class two quarters, at private study one quarter, and on vacation one quarter. However, in order to limit the length of this bulletin, attention will here be directed to a comparison of Program S with Programs A3 and B1.

Program A3 vs. Program S

From the standpoint of the student, Program A3 represents little change from Program S. Both schedules require the student to be in class two terms and off one term. Both lead to the B.S. degree in 3-2/3 years.

From the standpoint of the institution, Program A3 provides as low a cost index and as high use factors as any schedule considered. It thus provides the maximum advantages with the minimum disturbance to the conventional academic program.

From the standpoint of the faculty, Program A3 provides a 30 per cent increase in salary over Program S. However, this increase is gained by reducing the vacation time. Under Program A3 the recess and vacation periods total four weeks.

Table 7 shows the important factors of Programs S and A3 expressed in terms of Program S. That is, all factors of Program S are

Table 7

FACTORS OF PROGRAMS S AND A3 IN TERMS OF PROGRAM S

Factor	Actual Value		Relative Rating	
	Program S	Program A3	Program S	Program A3
G	0.2059P	0.3217P	100	156
P_m	108	206	100	190
G_c	$0.685T_a$	$0.539T_a$	100	78.7
U_i	0.730	0.946	100	130
U_r	0.830	0.923	100	111
U_t	0.661	0.923	100	139

given an arbitrary rating of 100, and the corresponding factors of Program A3 are given relative ratings.

It is apparent from Table 7 that an institution operating with Program A3 could grant 56% more degrees per year than it could under Program S. Furthermore, the cost per degree with Program A3 would be only 78.7% of that under Program S. The relative use factor of the instructional facilities would be 30% higher under Program A3 than with Program S, while the relative use factors of the research facilities and teaching staff would be 11% and 39% greater respectively. However, in order to realize these gains, the minimum enrollment would have to be 90% higher under Program A3 than under Program S (note relative values of P_m).

The importance of having all entering classes the same size is clearly seen by comparing Program A3' with Program A3. Instead of providing 56% more degrees (as does A3), Program A3' produces only 37% more than Program S. Other advantages are similarly reduced.

Some of the disadvantages which would arise in a change from Program S to Program A3 are listed below.

1. To realize maximum benefit in cost reduction, faculty members would have to serve for 48 weeks per year. This would eliminate the long summer vacation which is now available for developing course material and for maintaining contact with industry. However, to allow time for this activity, teachers under Program A3 could be required to teach less than full time during one of the three terms while being paid full salary for three terms, or they could be given one term off every few years. This sort of adjustment could eliminate any cost reduction but could be limited to maintain the same degree cost index as with Program S.
2. Many of the diversified activities now carried on during the summer under Program S would have to be eliminated under Program A3. These include such things as: in-service teacher training courses, Boy's and Girl's States, conferences, symposia, short courses, seminars, etc. (The usual summer session to provide courses for

deficient students would also have to be eliminated. However, there would be little need for such a session since all courses would be given in each term.)

3. Only one-third of the entering students could begin their college work in September. Another one-third would have to delay entrance until January, while the remainder would be detained until April. It would be difficult for a college to enforce the equal distribution among the three groups which is necessary for maximum efficiency. (Of course, this difficulty would be eliminated if all high schools as well as colleges were to adopt Program A3.)
4. The vacation periods for the students would come at different times. Some families would object to having a son's vacation at a different time from that of his father. (Some communities which have tested a public school schedule similar to *Program A3 have abandoned the* program largely because of family objections to unusual vacation periods.) It should be noted, however, that staggered vacation periods for the three groups of students might make it easier for industry to provide vacation-time employment. In this case a company could depend on a uniform supply of student help the year around.

Program B1 vs. Program S

The problems arising from having several admission dates and different vacation periods do not exist in Program B1. In this program, students are admitted once a year and are all on vacation at the same time. However, although Program B1 is the most efficient of those with a single admission and single vacation period, it is not as efficient as Program A3.

The number of degrees per year from Program B1 is 31% higher than the number with Program S (as compared with 56% higher for Program A3). The cost per degree with Program B1 is 88.5% of that under Program S (78.7% for Program A3). However, the plant capacity index for Program B1 is the lowest of any of the systems studied. The advantages of Program B1 could be realized with a minimum enrollment of only 76% of that needed for Program S.

The principal disadvantages of Program B1 are listed below.

1. To realize maximum cost reduction, faculty members would have to serve for 48 weeks per year. (See comment (1) regarding Program A3.)
2. Many of the diversified activities now carried on during the summer under Program S would have to be eliminated under Program B1. (See comment (2) regarding Program A3.)
3. Students would have only four free weeks per year and hence would have less opportunity to earn money during vacation periods. At the same time, the annual cost of attending college for three terms would be much greater than that under Program S. (Loan funds

could be established to aid students under Program B1. Note that only 2-2/3 years are required for the B.S. degree.)

4. Students might have only 16 to 19 days of summer vacation plus the Christmas recess. Of course, it would be possible to obtain approximately four weeks of summer vacation by eliminating the traditional Christmas recess.
5. Students would have less time in which to digest the subject matter. There would be no three-month vacation for reflection and reading.
6. Students would reach the senior year at an earlier age, and some might lack the maturity to obtain the maximum benefit from the advanced courses. (However, this acceleration would be an advantage to other students who might be able profitably to continue into graduate work.)

VII. CONCLUSIONS

By adopting a year-around schedule such as Program A3 in place of Program S, the nation's colleges could

(1) grant up to 56% more degrees per year,
(2) make up to 30% more use of instructional facilities,
(3) increase faculty salaries approximately 30%.

In order to gain these advantages it would be necessary to

(1) give up some summer activities such as conferences, symposia and short courses,
(2) reduce faculty vacations to four weeks,
(3) in some cases, alter the traditional pattern of starting time and vacation period for students,
(4) for maximum advantage, enforce uniform distribution of students among several entering classes per year.

LIST OF SYMBOLS

C -- Entire undergraduate class in first term = F + S + J + S.
D_1 -- Doctoral candidates in first term of first year after M. S.
D_1' -- Doctoral candidates in second term of first year after M. S.
D_2 -- Doctoral Candidates in first term of second year after M. S.
D_2' -- Doctoral candidates in second term of second year after M. S.
D_1'' -- First-year (after M. S.) doctoral candidates in third term of quarter system.
D_2'' -- Second-year (after M. S.) doctoral candidates in third term of quarter system.
E_1, E_2, E_3 -- Enrollments in first, second and third terms.
E_V -- Equivalent enrollment in recess and vacation period.
F -- First-term freshmen.
F' -- Second-term freshmen.
F'' -- Third-term freshmen in quarter system.
G -- Total number of degrees granted in one year = $G_B + G_M + G_D$.
G_B -- Graduates with B. S. degree from one class.
G_c -- Degree cost index, ratio of total annual operating cost to number of degrees granted in one year.
G_M -- Graduates with M. S. degree from one class.
G_D -- Graduates with Ph. D. degree from one class.
J -- First-term juniors.
J' -- Second-term juniors.
J'' -- Third-term juniors in quarter system.
M -- First-term candidates for M. S.
M' -- Second-term candidates for M. S.
M'' -- Third-term candidates for M. S. in quarter system.
N_1, N_2, N_3, N_V -- Numbers of equivalent full-time teachers needed for instruction in each of three terms and in the recess and vacation period.
N_F, N_S, N_J, N_S, N_M, N_{D_1}, N_{D_2} -- numbers of teachers needed for first term in each grade.
$N_{F'}$, $N_{S'}$, $N_{J'}$, $N_{S'}$, $N_{M'}$, $N_{D_1'}$, $N_{D_2'}$ -- Numbers of teachers required for second term in each grade.
N_m -- Number of equivalent full-time teachers needed to carry maximum teaching load.
P -- Maximum number of students which can be accommodated in instructional facilities at any one time.
P_m -- Plant capacity index.
q -- Ratio of total operating cost to total teaching salaries.
Q -- Total annual operating cost.

R -- Number of equivalent full-time research workers for which research facilities are designed.
R_1, R_2, R_3 -- Numbers of research workers in first, second and third terms.
R_V -- Average number of research workers during recess and vacation period.
S -- First-term sophomores.
S' -- Second-term sophomores.
S" -- Third-term sophomores in quarter system.
$\underline{S}$ -- First-term seniors.
$\underline{S}'$ -- Second-term seniors.
$\underline{S}''$ -- Third-term seniors in quarter system.
$\overline{T}$ -- Average annual teaching salary.
T_a -- Average academic-year salary paid for present standard two-semester year.
U_{ai1}, U_{ai2}, U_{ai3}, U_{aiv} -- Actual use factors of instructional facilities for three regular terms and a period of recess and vacation.
U_i -- Relative use factor of instructional facilities.
U_{ii} -- Ideal use factor of instructional facilities.
U_r -- Relative use factor of research facilities.
U_t -- Relative use factor of teaching staff.
W_1, W_2, W_3, W_V -- Numbers of weeks in first, second and third terms and in period of recess and vacation.

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